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P01/7700 0.00-9926717.1

Request for grant of a patent

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1.	Your reference	R037602PGB
2.	Patent application number *(The Patent Office will fill in this part)*	9926717.1 12 NOV 1999
3.	Full name, address, and postcode of the or of each applicant *(underline all surnames)*	Lucas Industries Limited 46 Park Street, London, W1Y 4DJ, ENGLAND
	Patents ADP number *(if you know it)*	7474422001
	If the applicant is a corporate body, give the country/state of its incorporation	A British Company
4.	Title of the invention	BRAKE ASSEMBLY
5.	Name of your agent *(if you have one)*	Marks & Clerk
	"Address for Service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	Alpha Tower Suffolk Street Queensway Birmingham B1 1TT
	Patents ADP number *(if you know it)*	18002
6.	If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number	Country Priority application number *(if you know it)* Date of filing *(day / month / year)*
7.	If this application is divided or otherwise derived from an earlier UK application give the number and filing date of the earlier application	Number of earlier application Date of filing *(day / month / year)*
8.	Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:* *a) any applicant named in part 3 is not an inventor, or* *b) there is an inventor who is not named as applicant, or* *c) any named applicant is a corporate body.* *See note (d))*	Yes

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Description	12 8K
Claim(s)	
Abstract	
Drawing(s)	1 + 1

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Priority documents	
Translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
Request for preliminary examination and search *(Patents Form 9/77)*	
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	

11. I/We request the grant of a patent on the basis of this application.

Signature

Date 11 NOV 1999

12. Name and daytime telephone number of person to contact in the United Kingdom: Joanne POPLE (0121 643 5881)

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BRAKE ASSEMBLY

This invention relates to a brake assembly. In particular, the invention relates to a brake assembly suitable for use with an electric motor to slow or stop the motor or to hold the motor in a selected position. The invention is particularly suitable for use in aerospace applications.

Electric motors are used in a range of aerospace applications, for example to drive hatches or doors between their open and closed positions or to drive aircraft wing flaps or the like. In some applications, where rapid movement is to be achieved, the motor must be able to rotate at very high speeds. It is important, in such applications, to provide a brake assembly to permit rapid deceleration of the motor to avoid damage to the aircraft when the hatch, door, flap or other component approaches the end of its range of movement, or to stop the component in a desired location. Additionally, the brake assembly may be required to operate as a primary or secondary holding means to prevent movement of the hatch, door or flap away from a predetermined position.

In a typical brake assembly, for example as described in US 4921078, a plurality of brake discs are provided, alternate ones of the brake discs being rotatable with the output shaft of the motor, the remaining discs being non-rotatable. An electromagnetic actuator is provided to control the compressive load applied to the discs, thereby controlling the magnitude of a braking force applied to the motor. The discs are typically formed from steel, phosphor bronze or a combination of both and typically have a friction coefficient

falling within the range 0.1 to 0.2. Brake assemblies of this type operate whilst immersed in oil to avoid excessive wear or for cooling purposes.

For a number of applications, such a brake assembly provides an adequate braking force. However, in aerospace applications, where component weight and size are of great importance, the number and size of traditional brake discs required may result in an undesirably large and heavy assembly. Also, in some high load applications, for example, it is desirable to be able to apply a greater braking force, for example to stop a motor operating at speeds of the order of 15,000 rpm within a fraction of a second.

Our co-pending British Patent Application No 9914003.0 describes a brake assembly including a stack of brake elements, at least one of which is rotatable with an output shaft of a motor and at least one of which is fixed relative to the shaft. The brake assembly includes an actuator for controlling the magnitude of the compressive load applied to the brake elements. The brake elements are provided, at least in part, with a surface coating which raises the coefficient of friction of the brake elements to a value greater than 0.2. The brake assembly has an improved brake efficiency, permitting the use of a smaller number of brake elements than in conventional arrangements and thereby significantly reducing the weight of the assembly.

For some applications, however, it may be necessary to orient the motor in such a way that the axis of the output shaft is substantially vertical. This is the case, for example, if the motor is employed to drive a wing flap on an aircraft. However, with the output shaft in this orientation, the brake elements can be caused to contact one another under the influence of gravity

when the brake is de-actuated. This results in an undesirable drag force being applied to the motor during points in the operation of the motor where rotation of the output shaft is desired.

It is an object of the present invention to provide an improved brake assembly which alleviates or overcomes the aforementioned disadvantages.

According to an aspect of the invention there is provided a brake assembly for a motor, the brake assembly comprising a stack of brake elements, at least one of which is rotatable with an output shaft of the motor, in use, and at least one of which is non-rotatable relative to a housing, and actuator means controlling the magnitude of a compressive load applied to the brake elements, wherein the brake elements are provided, at least in part, with a surface coating which raises the coefficient of friction of the brake elements to a value greater than 0.2.

Preferably, the stack of brake elements may take the form of a first brake element which is rotatable with the output shaft of the motor, in use, and a second brake element which is non-rotatable relative to the housing. Conveniently, the second brake element forms part of a cap forming part of the housing.

Preferably, the brake assembly includes means for preventing contact between the first and second brake elements when the actuator means are de-actuated.

Thus, even if the motor is oriented such that the output shaft is arranged substantially vertically and the first brake element is urged towards the second brake element under the influence of gravity, no contact will occur between the first brake element and the second brake element when the brake is de-actuated. This prevents an undesirable drag force being applied to the motor during points in the operation when it is desired for the motor to rotate freely. The motor can therefore be used in any orientation.

The first brake element may conveniently take the form of a brake disc.

The actuator means may comprise an electromagnetic actuator arranged to act against a primary spring. In such an arrangement, it may be desirable to form the brake elements from a non-magnetic material.

Conveniently, the means for preventing contact between the first and second brake elements includes biasing means for biasing the first brake element away from the second brake element, the biasing means providing a biasing force which exceeds the weight of the first brake element.

The biasing means may conveniently take the form of a secondary spring, the spring force due to the secondary spring being sufficient to overcome the weight of the first brake element but being less than the spring force due to the primary spring.

The means for preventing contact between the first and second brake elements may further comprise a stop member arranged to limit axial

movement of the first brake element relative to an armature forming part of the actuator means.

Conveniently, the stop member may take the form of a shoulder provided on a rotor shaft which is rotatable with the output shaft of the motor. The rotor shaft may preferably form an integral part of the output shaft.

The rotor shaft may be provided with an abutment member, the secondary spring being located between the abutment member and the first brake element. Conveniently, the abutment member takes the form of a flange provided on the rotor shaft.

The surface coating conveniently raises the coefficient of friction to a value of at least 0.5, the coefficient of friction conveniently falling within the range 0.5 to 0.6. The provision of the surface coating dramatically improves the brake efficiency of the assembly, permitting the use of a smaller number of brake elements than in the conventional arrangements, resulting in a significant weight reduction. Further, the means controlling the magnitude of the compressive load can be of reduced weight as the magnitude of the compressive load applied to the brake elements can be reduced.

The surface coating is preferably tungsten carbide which may be applied using a detonation gun deposition technique and conveniently forms a layer of thickness falling within the range 0.025" to 0.050" (0.64 mm to 1.27 mm).

Preferably, the brake elements form part of a module which can be removed from the motor and the remainder of the brake assembly as a unit. The

module may further include the armature forming part of the actuator. The surface coating may also be applied to at least a part of the surface of the armature which is contactable with the first brake element.

By manufacturing the module relatively accurately, the brake elements can be replaced by replacing the module with a new module, no significant setting or adjustment being required before the brake assembly is suitable for use.

The invention will now be described, by way of example only, with reference to the accompanying drawing, in which there is shown a sectional view illustrating a brake assembly for a motor in accordance with an embodiment of the invention.

The accompanying drawing illustrates a motor comprising a housing 10 within which a stator 11 is mounted. A rotor 12 is rotatable under the influence of a magnetic field generated, in use, by the stator 11. The rotor 12 includes an output shaft 13 which projects from an end of the housing 10, the output shaft 13 being coupled, in use, through a suitable gearing arrangement to an input of a device to be operated by the motor. For example, the device may take the form of a rotary actuator for driving an aircraft wing flap between a closed position and an open position. Where the aircraft wing flap is to be moved between its fully closed and fully open positions, it will be appreciated that when the flap approaches one of its extreme positions, in order to avoid damage being caused to the flap or to the operating mechanism, it is desirable to brake the movement of the wing flap. Additionally, after the flap has been moved to the required position, it is desirable to hold the flap against unrequired movement due to air flow. This

is achieved using a brake assembly, referred to generally as 14, associated with the motor to slow or stop the rotation thereof.

The brake assembly 14 comprises a first brake element in the form of a brake disc or plate 15a which is keyed to a rotor shaft 16 which is rotatable with the rotor 12 of the motor through a spline arrangement 17. The spline arrangement 17 is arranged such that the brake disc 15a is rotatable with the shaft 16 and is free to move axially relative to the shaft 16 by a predetermined, limited distance. The brake assembly 14 also includes a second brake element 15b, the brake element 15b forming part of a cap 19 which is non-rotatably mounted upon the housing 10 of the motor. The cap 19 cooperates with a closure member 32 which is removable from the cap 19 to enable the brake disc 15a and the brake element 15b to be accessed, if desired.

The cap 19 may be mounted upon the housing 10 using any suitable technique, for example using bolts (not shown). Typically, the brake element 15b may be formed by machining the cap 19 such that the brake element 15b forms an integral part of the cap 19. It will be appreciated, however, that the brake element 15b may be a separate component which is mounted upon the cap 19 such that relative rotation between the brake element 15b and the cap 19 is prevented.

At its end remote from the rotor 12, the shaft 16 includes an abutment member in the form of a flange 16a which is rotatable with the shaft 16, a surface of the flange 16a being in abutment with one end of a biasing spring 30. The other end of the biasing spring 30 is in abutment with the rotatable

brake disc 15a, the spring 30 being mounted such that, in use, it rotates with the shaft 16. The shaft 16 is also provided with a stop member 16b, the spring 30 applying a biasing force to the rotatable brake disc 15a which serves to urge the brake disc 15a towards the stop member 16b so as to limit axial movement of the brake disc 15a. The stop member 16b is conveniently formed on the shaft 16 by cutting the spline arrangement 17 across two diameters thereof so as to provide a full spline and a shoulder on the shaft 16 which forms the stop member 16b. The spring force of the spring 30 acts against the spring force of the spring 23, but provides only limited resistance thereto. The spring force of the spring 30 is, however, sufficient to overcome the weight of the rotatable brake disc 15a.

The brake assembly 14 also includes an electromagnetic actuator 20 which is mounted within the housing 10. The actuator 20 comprises an energization coil or winding 21 which is arranged such that energization thereof attracts an armature 22 towards the winding 21 against the action of a biasing spring 23. The actuator 20 includes a support member 24 which carries the winding 21 and which serves as an abutment for the spring 23. The support member 24 further carries a bearing which guides the shaft 16 for rotary movement within the housing 10. The support member 24 may be secured to the housing 10 by any suitable technique, for example by means of bolts (not shown).

The brake disc 15a and the brake element 15b are conveniently constructed from a non-magnetic alloy, for example beryllium copper, to which a surface coating has been applied to increase the coefficient friction of the brake elements 15a, 15b. Preferably, the surface coating is applied to both surfaces

of the brake disc 15a, the surface of the brake element 15b facing the brake disc 15a and the surface of the armature 22 facing the brake disc 15a. The coating may comprise, for example, a tungsten carbide material coating which has been applied to form a layer of thickness falling within the range 0.64 to 1.27 mm, for example using a detonation gun deposition technique. A suitable material for the coating is a tungsten carbide material sold by Union Carbide under the name UCAR WL 1N40. The application of such a surface coating raises the coefficient of friction of the brake elements to a value falling within the range 0.5 to 0.6. As a result, braking efficiency is improved, and consequently, it is only necessary to include two brake elements in order to provide a sufficient braking effect to the motor. Furthermore, the surface coating has particularly advantageous wear resistance, enabling the brake assembly to be operated without being immersed in oil.

In use, with the winding 21 de-energized, the spring 23 biases the armature 22 to apply a compressive load to the brake disc 15a and, as the force due to the spring 23 exceeds the opposing force due to the spring 30, the brake disc 15a is urged to move axially against the brake element 15b. The compressive load applied to the brake disc 15a therefore applies a braking force to the shaft 16, countering rotation thereof, and hence to the rotor 12 of the motor. Energization of the winding 21 attracts the armature 22 towards the winding 21 countering the effect of the spring force due to the spring 23. As a result, the magnitude of the compressive load applied to the brake disc 15a is reduced. A reduction in the compressive load causes the brake disc 15a to move away from the brake element 15b due to the force of the spring 30, axial movement of the brake disc 15a away from the brake element 15b being

terminated when the brake disc 15a abuts the stop member 16b. As the brake disc 15a separates from the brake element 15b, the braking force applied to the shaft 16 and the rotor 12 is removed such that rotation of the shaft 16 is permitted.

If the motor is oriented such that the axis of the shaft 16 is vertically aligned, the provision of the spring 30 ensures the brake disc 15a is prevented from pressing against the brake element 15b under the influence of gravity. The provision of the stop 16b ensures that axial movement of the brake disc 15a is limited such that, under such circumstances, the force due to the spring 30 does not cause contact between the surface of the brake disc 15a and the armature 22. Thus, when the winding 21 is energised to remove the braking force applied to the shaft 16 and it is desired for the rotor 12 to rotate freely, any drag force which would otherwise occur due to contact between the brake disc 15a and the brake element 15b is prevented. Due to the increased coefficient friction of the brake elements 15a, 15b, it is particularly desirable to avoid any such contact between the surfaces of the elements 15a, 15b at points in the operation of the motor in which the brake is not being applied as such contact would impede operation of the motor and generate additional heat. Thus, the brake assembly is capable of operating in any orientation and, additionally, operation will not be effected by any vibration caused by operation of the motor.

The use of a tungsten carbide coating not only increases the friction coefficient of the brake elements 15a, 15b, but is also able to withstand high temperatures, in the region of 1000°C, which can be generated upon repeated use of the brake assembly. The increased braking efficiency further permits

an actuator 20 of reduced dimensions and weight to be used, whilst still achieving the necessary braking effect as the magnitude of the compressive load necessary to achieve the desired braking effect is reduced.

A further advantage of the arrangement illustrated in the accompanying drawing is that, when the brake assembly requires servicing, the cap 19 may be removed easily from the housing 10. The brake assembly is designed such that removal of the cap 19, including the brake element 15b, from the housing 10 results in the armature 22 and the brake disc 15a being removed from the remainder of the brake assembly, the removal of the cap 19 causing the brake disc 15a which, in use, is keyed through the spline arrangement 17 to the shaft 16, to become disengaged therefrom. The cap 19, including the brake element 15b, the brake disc 15a and the armature 22 can therefore be removed from the motor and the remainder of the brake assembly as a single unit or module. During normal servicing, it is unlikely that the winding 21 will require replacement or maintenance and, thus, the support member 24 can be left in position. As the brake assembly is designed in such a manner that only the module consisting of the cap 19, the brake disc 15a, and the armature 22 needs to be removed from the motor during normal servicing or maintenance, there is no need to replace the winding 21 during each servicing operation. As a result, the servicing operation can be achieved more efficiently, requiring the replacement of fewer parts. The provision of the removable closure member 32 permits the brake assembly to be accessed without the need to remove the cap 19, if desired.

Although in the description hereinbefore the brake force is applied at points in the operation other than when the winding 21 is energized, it will be

appreciated that arrangements are possible in which the application of the braking force occurs where the winding is energized. Although the brake assembly 14 is particularly suitable for use as a brake for a motor for driving an aircraft wing flap, it will be appreciated that the invention is suitable for use in other applications, particularly those in which the motor is oriented such that the brake disc 15a will be urged towards the brake element 15b under the influence of gravity at points in the operation of the motor where no braking force is required.

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